9 Gravitation

Fastrack Revision

- **Gravitational Force:** It is the force of attraction between any two objects in the universe.
- **Gravity:** It is the force with which the Earth pulls the objects towards its centre.
- **Universal Law of Gravitation:** This law was given by Isaac Newton and states that, 'the force of attraction between any two objects in the universe is directly proportional to the product of their masses and inversely proportional to the square of distance between them'

$$\text{Gravitational force, } F = \frac{GMm}{d^2}$$

Here, $G = 6.673 \times 10^{-11}$ N-m^2 kg^{-2} is the universal gravitation constant.

The direction of the force is along the line joining the centres of two object.

- **Importance of the Universal Law of Gravitation**

The universal law of gravitation successfully explained several phenomena which are as follows:

  - the force that binds us to Earth,
  - the motion of the Moon around the Earth,
  - the motion of planets around the Sun, and
  - the tides due to the Moon and the Sun.

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The strength of gravitational attraction between two objects depends on how big the objects are and how far apart they are.

- **Centripetal Force:** It is the force that keeps a body moving along the circular path, to act towards the centre and is responsible for the change in direction of velocity or acceleration, *e.g.*, motion of Moon around the Earth.
- **Free Fall:** It is the motion of objects that fall towards the Earth under the Earth's gravitational force alone.
- **Acceleration Due to Gravity (g):** It is the acceleration due to the Earth's gravitational pull when an object falls towards the Earth. It does not depend on the mass of a falling object but on the mass of the Earth or celestial bodies.

$$g = \frac{GM}{R^2}$$

where M = mass of Earth, R = radius of Earth and $g = 9.8\ \text{m s}^{-2}$

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The value of g decreases as the distance of an object from the centre of the celestial body increases and this value is less at equator than at poles.

- **Motion of Objects under the Influence of Gravitational Force**

General equations of motion	Equations of motion for a freely falling body	Equations of motion for a body thrown vertically upward
$v = u + at$	$v = u + gt$	$v = u - gt$
$s = ut + \frac{1}{2}at^2$	$h = ut + \frac{1}{2}gt^2$	$h = ut - \frac{1}{2}gt^2$
$v^2 = u^2 + 2as$	$v^2 = u^2 + 2gh$	$v^2 = u^2 - 2gh$

- **Mass:** It is the total quantity of material contained in an object. Its SI unit is Kilogram (kg) and is a scalar quantity. The mass of an object is constant and does not change from place to place.

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Spring balance is used to measure the weight of an object and pan balance is used to measure the mass of an object.

- **Weight:** It is the force with which an object is attracted towards the Earth. It is the product of mass and acceleration due to gravity. Its SI unit is Newton (N) and is a vector quantity. Weight of an object depends on its location and may have different values at different places.
- **Weight of an Object on the Moon:** It is one-sixth of its weight on the Earth.
- **Thrust:** It is the force acting on an object in perpendicular direction to its surface. Its SI unit is Newton (N) and is a vector quantity.
- **Pressure:** It is the force acting on the unit area of surface in perpendicular direction. Its SI unit is Newton per metre square (Nm^{-2}) and is a scalar quantity. The SI unit of pressure is also called Pascal (Pa).

$$\text{Pressure} = \frac{\text{Thrust}}{\text{Area}} = \frac{F}{A}$$

- **Pressure in Fluids:** Fluids exert pressure on the base and walls of the container in which they are enclosed and the pressure exerted on fluids is transmitted equally in all directions.

- **Buoyancy:** It is the tendency of a liquid to exert an upward force on an object immersed in it.
- **Buoyant Force:** It is the upward force which acts on an object when it is immersed in a liquid. It is also called upthrust.
- **Factors Affecting Buoyant Force:** The magnitude of buoyant force depends on density of the fluid and the volume of object immersed in the liquid.

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It is the buoyant force due to which heavy object seems to be lighter in water. This reduced weight of an object in liquid is called apparent weight.

- **Floating or Sinking of Objects:** The conditions are:
  - If the buoyant force or upthrust exerted by the liquid is less than the weight of the object, the object will sink in the liquid.
  - If the buoyant force is equal to the weight of the object, the object will float in the liquid.
  - If the buoyant force is more than the weight of the object, the object will rise in the liquid and then it will float.
- **Archimedes' Principle:** 'When an object is fully or partially immersed in a fluid, it experiences a buoyant force or upthrust which is equal to the weight of liquid displaced by the object'.

Upthrust acting on an object = Weight of liquid displaced by an object

Knowledge BOOSTER

Density is used to determine the purity of a substance and decreases with the increase in temperature.

Applications of Archimedes' Principle: It is used in:
- designing ships and submarines.
- lactometers (used to determine the purity of a sample of milk).
- hydrometers (used for determining density of liquids).

- **Density:** It is the mass per unit volume of a substance. Its SI unit is kilogram per metre cube (kg m^{-3}) and is a scalar quantity.

Practice Exercise

Multiple Choice Questions

Q 1. Which of the following case do not take place due to gravitational force?
a. Earth revolution around Sun
b. Magnet attracting iron nails
c. Apple falling from a tree
d. All are due to gravity

Q 2. What is the unit of universal gravitational constant?
a. Newton $(metre)^2$ $(kilogram)^{-2}$
b. Newton $(metre)^{-2}$ $(kilogram)^{-1}$
c. Newton $(metre)^2$ $(kilogram)^2$
d. Newton $(metre)^2$ $(kilogram)^{-1}$

Q 3. The force of attraction between two unit point masses separated by a unit distance is called: *(NCERT EXEMPLAR)*
a. gravitational potential
b. acceleration due to gravity
c. gravitational field
d. universal gravitational constant

Q 4. Law of gravitation gives the gravitational force between: *(NCERT EXEMPLAR)*
a. the Earth and a point mass only
b. the Earth and Sun only
c. any two bodies having some mass
d. two charged bodies only

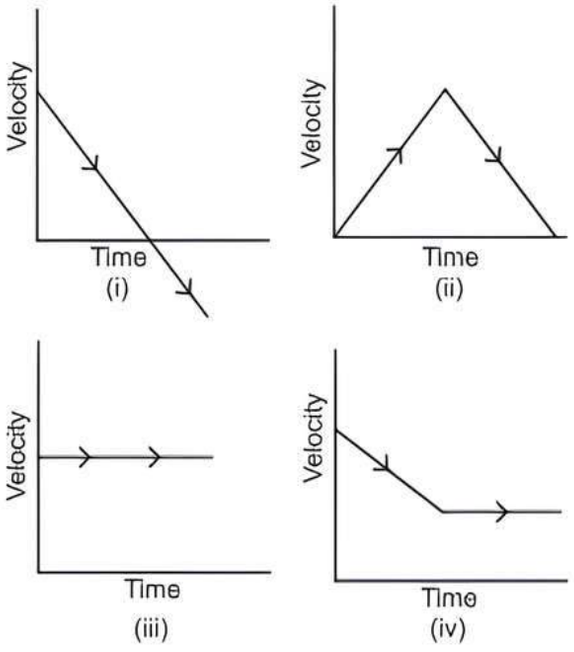
Q 5. The value of quantity G in the law of gravitation: *(NCERT EXEMPLAR)*
a. depends on mass of Earth only
b. depends on radius of Earth only
c. depends on both mass and radius of Earth
d. is independent of mass and radius of the Earth

Q 6. Find the gravitational force between two spheres of mass m and $m/2$ having radius x and in contact with each other:
a. $\frac{Gm^2}{2x^2}$ b. $\frac{Gm^2}{x^2}$
c. $\frac{Gm^2}{4x^2}$ d. $\frac{Gm^2}{8x^2}$

Q 7. The gravitational force between two objects is F. If masses of both objects are halved without changing distance between them, then the gravitational force would become: *(NCERT EXEMPLAR)*
a. $F/4$ b. $F/2$
c. F d. $2F$

Q 8. A boy is whirling a stone tied with a string in an horizontal circular path. If the string breaks, the stone: *(NCERT EXEMPLAR)*
a. will continue to move in the circular path
b. will move along a straight line towards the centre of the circular path
c. will move along a straight line tangential to the circular path
d. will move along a straight line perpendicular to the circular path away from the boy

Q 9. Which of the following graph represents the motion of a ball when thrown upwards?



a. (I) b. (II)
c. (III) d. (IV)

Q 10. Two objects of different masses falling freely near the surface of Moon would: *(NCERT EXEMPLAR)*

a. have same velocities at any instant
b. have different accelerations
c. experience forces of same magnitude
d. undergo a change in their inertia

Q 11. The value of acceleration due to gravity: *(NCERT EXEMPLAR)*

a. is same on equator and poles
b. is least on poles
c. is least on equator
d. increases from pole to equator

Q 12. What is the value of universal gravitational constant on Moon if its value is *G* on Earth?

a. *G* b. *G*/6
c. *G*/3 d. *G*/2

Q 13. Why is the weight of an object less on the Moon than on Earth?

a. Density of Moon is less than density of Earth
b. Moon is a satellite of Earth
c. Moon is far from Earth
d. Moon's gravitational force is less than that of Earth

Q 14. The weight of an object at the centre of the Earth of radius *R* is: *(NCERT EXEMPLAR)*

a. zero
b. infinite
c. *R* times the weight at the surface of the Earth
d. $1/R^2$ times the weight at surface of the Earth

Q 15. The weight of a body is 120 N on the Earth. If it is taken to the Moon, its weight and mass will be about

a. 120 N, 120 kg b. 60 N, 12 kg
c. 20 N, 12 kg d. 720 N, 120 kg

Q 16. The SI unit of thrust is same as that of:

a. Force/Area b. Force × Area
c. Force d. None of these

Q 17. With increase in surface area, pressure:

a. increases
b. decreases
c. remains unchanged
d. becomes zero

Q 18. A girl stands on a box having 60 cm length, 40 cm breadth and 20 cm width in three ways. In which of the following cases, pressure exerted by the brick will be: *(NCERT EXEMPLAR)*

a. maximum when length and breadth form the base
b. maximum when breadth and width form the base
c. maximum when width and length form the base
d. the same in all the above three cases

Q 19. The buoyancy depends on:

a. mass of liquid displaced
b. viscosity of the liquid
c. pressure of the liquid displaced
d. depth of immersion

Q 20. An object is put one by one in three liquids having different densities. The object floats with $\frac{1}{9}$, $\frac{2}{11}$ and $\frac{3}{7}$ parts of their volumes outside the liquid surface in liquids of densities d_1, d_2 and d_3 respectively. Which of the following statement is correct? *(NCERT EXEMPLAR)*

a. $d_1 > d_2 > d_3$ b. $d_1 > d_2 < d_3$
c. $d_1 < d_2 > d_3$ d. $d_1 < d_2 < d_3$

Q 21. The density of a metal block is 2.7×10^3 kg/m^3. It is immersed in water. State the situation.

a. metal will sink
b. metal will float
c. metal will immersed partially
d. None of the above

Q 22. Archimedes' principle states that the buoyant force applied to an object:

a. is greater than the weight of the fluid displaced by it.
b. is equal to the weight of the fluid displaced by it.
c. is less than the weight of the fluid displaced by it.
d. is zero.

Q 23. An object weight 10 N in air. When immersed fully in water, it weights only 8 N. The weight of the liquid displaced by the object will be:

a. 2 N b. 8 N
c. 10 N d. 12 N

Assertion & Reason Type Questions

Directions (Q. Nos. 24-32): *Each of the following questions consists of two statements, one is Assertion (A) and the other is Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below:*

a. Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
b. Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).
c. Assertion (A) is true but Reason (R) is false.
d. Assertion (A) is false but Reason (R) is true.

Q 24. Assertion (A): When the distance between the two bodies is doubled and also the mass of each body is also doubled, the gravitational force between them remains the same.
Reason (R): According to Newton's law of gravitation, force is directly proportional to the mass of bodies and inversely proportional to the square of distance between them.

Q 25. Assertion (A): The Earth is acted upon by gravitation of the Sun, even though it does not fall into the Sun.
Reason (R): The gravitational pull of the Sun on the earth provides the required centripetal force on earth due to which it revolves around the Sun.

Q 26. Assertion (A): The value of acceleration due to gravity does not depend upon mass of the body on which force is applied.
Reason (R): Acceleration due to gravity is a constant quantity.

Q 27. Assertion (A): A body becomes weightless at the centre of Earth.
Reason (R): As the distance from centre of Earth decreases, acceleration due to gravity increases.

Q 28. Assertion (A): The universal gravitational constant is same as acceleration due to gravity.
Reason (R): Gravitational constant and acceleration due to gravity do not have same SI unit.

Q 29. Assertion (A): Pins and nails are made to have pointed ends in order to have a minimum area of contact between the pointed ends and the given surface.
Reason (R): Minimal area of contact means that the pressure applied on the surface by the pin is greater.

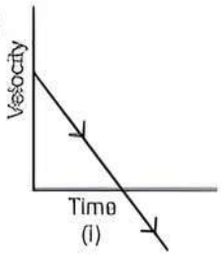
Q 30. Assertion (A): An object will sink in water when the downward force acting on that object is greater than the upthrust of water on that object.
Reason (R): An object will sink in water when upthrust of water on that object is greater than the weight of that object.

Q 31. Assertion (A): An object floats if it displaces an amount of liquid whose weight is greater than the actual weight of the object.
Reason (R): During flotation an object experiences no net force in the downward direction.

Q 32. Assertion (A): Archimedes' principle gives a relationship between buoyant force exerted by a liquid on an object and the weight of liquid displaced by it.
Reason (R): Hydrometers and lactometers are based on Archimedes' principle.

Answers

1. (b) Magnet attracting iron nails
2. (a) Newton (metre)^2 (kilogram)$^{-2}$
   We know that,
   Universal gravitational constant, $G = \frac{Fd^2}{M \times m}$
   S.I. unit of $G = \frac{Nm^2}{kg^2}$
3. (d) universal gravitational constant
4. (c) any two bodies having some mass
5. (d) is independent of mass and radius of the Earth
   G is the constant of proportionality and is independent of mass and radius of the Earth.
6. (a) $\frac{Gm^2}{2x^2}$
   We know that,
   $$F = G\frac{M \times m}{d^2}$$
   $$F = G\frac{m \times \frac{m}{2}}{x^2} = \frac{Gm^2}{2x^2}$$
7. (a) F/4
   $$F = G\frac{M \times m}{d^2}$$
   $$F = G\frac{\frac{M}{2} \times \frac{m}{2}}{d^2} = \frac{GM \times m}{4d^2} = \frac{F}{4}$$
8. (c) will move along a straight line tangential to the circular path
9. (a)



   When a ball is thrown vertically upwards with velocity 'u' and its velocity 'v' after time 't' is:
   $$v = u - gt$$
   It is a straight line graph with negative slope.
   Hence, option (a) is correct.
10. (a) have same velocities at any instant
    In free fall, velocity depends only on the acceleration produced by gravity. The acceleration due to gravity is independent of mass of the body. Hence, same acceleration due to gravity of Moon is applied on both objects. So, they will have same velocities at any instant irrespective of their masses. The two will not experience the same force as force is dependent on mass and mass of body is different here.

11. (c) is least on equator

We know that, $g = \frac{Gm}{R^2}$

Since, R is maximum at equator, value of acceleration due to gravity is least on equator.

12. (a) G

The value of universal gravitational constant (G) remains constant everywhere in the universe.

13. (d) Moon's gravitational force is less than that of Earth

14. (a) Zero

$W = mg = m \times 0 = 0$

15. (c) 20 N, 12 kg

Weight of object on Moon $= \frac{1}{6}$ × Weight of object on earth

$= \frac{1}{6} \times 120 = 20$ N

We know that, $w_e = m_e g$

$\Rightarrow \quad 120 = m \times 10$

$\Rightarrow \quad m = 12$ kg

Mass of object on Earth = Mass of object on Moon = 12 kg

16. (c) Force

17. (b) decreases

Pressure is inversely proportional to area.

18. (b) maximum when breadth and width form the base

Pressure is maximum when area of base is minimum. Area of base is minimum when breadth and width form the base.

19. (a) mass of liquid displaced

20. (d) $d_1 < d_2 < d_3$

When an object floats in liquid, a buoyant force acts on it, which is equal to the weight of liquid displaced by that object. As more part of object's volume floats outside the liquid, more is the buoyant force and higher is the density of liquid.

So, $d_1 < d_2 < d_3 \quad \left(\because \frac{1}{9} < \frac{2}{11} < \frac{3}{7}\right)$

21. (a) metal will sink

Given, density of metal = 2.7×10^3 kg/m^3

Density of water = 1000 kg/m^3

Density of metal > Density of water

So, metal will sink.

22. (b) is equal to the weight of the fluid displaced by it.

23. (a) 2N

Weight of liquid displaced by object = Loss in weight of the object = 10 N – 8 N = 2 N

24. (a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

25. (a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

26. (c) Assertion (A) is true but Reason (R) is false.

Reason (R) is false because acceleration due to gravity changes with respect to height above the Earth surface, depth below the Earth surface or due to shape of Earth (g is greater at poles than at equator).

27. (c) Assertion (A) is true but Reason (R) is false.

Reason (R) is false because, as distance from centre of Earth decreases, the acceleration due to gravity also decreases.

28. (d) Assertion is false because universal gravitational constant (G) and acceleration due to gravity (g) are different.

G is a scalar quantity whereas g is a vector quantity.

SI unit of G is Nm^2 Kg^{-2} and SI unit of g is m s^{-2}.

29. (a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

30. (c) Assertion (A) is true but Reason (R) is false.

Reason (R) is false because an object will sink in water when upthrust of water on that object is less than the weight of that object.

31. (b) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).

32. (b) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).

Case Study Based Questions

Case Study 1

Universal law of gravitation states that every object in the universe attracts every other object with a force which is directly proportional to the product of their masses and inversely proportional to the square of the distance between them. The direction of force is along the line joining the centres of the two bodies. The law is universal in the sense that it is applicable to all bodies, whether the bodies are big or small, whether they are celestial or terrestrial.

Read the given passage carefully and give the answer of the following questions:

Q 1. The universal law of gravitation was postulated by:

a. Copernicus b. Newton

c. Galileo d. Archimedes

Q 2. Which of the following is true for the universal law of gravitation?

(i) It acts on all the objects irrespective of their nature, shape and size

(ii) $F \propto M \times m$

(iii) It acts along the line joining the centres of the two objects.

(iv) $F \propto 1/d^2$

a. (i) and (iii) b. (ii) and (iv)

c. (i), (ii) and (iv) d. All of these

Q 3. The mass of a body is increased 4 fold and mass of other body is increased 16 fold. How should the distance between them be changed to keep the same gravitational force between them?

a. 4 times b. $\frac{1}{4}$ times c. 8 times d. $\frac{1}{8}$ times

Q 4. Which of the following is not true for universal law of gravitation?

a. It is the gravitational force between the Sun and the Earth, which makes the Earth move around the Sun.

b. The tides formed in sea are because of gravitational pull exerted by the Sun and the Moon on the surface of water.

c. It is the gravitational pull of the Earth which keeps us and other bodies firmly on the ground.

d. The gravitational force exerted by Sun on Earth is larger than that exerted by Earth on Sun.

Q 5. The force of gravitation between two bodies of mass 1 kg each kept at a distance of 1 m is:

a. 6.67 N b. 6.67×10^{-9} N

c. 6.67×10^{-7} N d. 6.67×10^{-11} N

Answers

1. (b) Newton

2. (d) All of these

We know that,

$F \propto \frac{M \times m}{d^2}$;

i.e., $F \propto M \times m$ and $F \propto \frac{1}{d^2}$

It acts along the line joining the centres of those objects and it is said to be universal because it is applicable to all objects.

3. (c) 8 times

$$F = \frac{Gm_1 m_2}{d^2} = \frac{G(4m_1)(16m_2)}{d'^2}$$

$\therefore \quad d'^2 = 64d^2 \quad$ or $\quad d' = 8d$

4. (d) The gravitational force exerted by Sun on Earth is larger than that exerted by Earth on Sun.

5. (d) 6.62×10^{-11} N

Force, $F = \frac{Gm_1 m_2}{r^2}$;

Given, $m_1 = m_2 = 1$ kg, $r = 1$ m

$F = G = 6.67 \times 10^{-11}$ N

Case Study 2

The uniform acceleration produced in a freely falling body due to the gravitational force of the Earth is known as acceleration due to gravity and it is denoted by the letter g. The value of acceleration due to gravity of the Earth, $g = 9.8\ ms^{-2}$. The value of acceleration due to gravity, g, is not constant at all the places on the surface of the Earth.

Read the given passage carefully and give the answer of the following questions:

Q 1. Acceleration due to gravity of a body during free fall does not depend upon the:

a. mass of Earth
b. mass of falling body
c. universal gravitational constant
d. radius of Earth

Q 2. When a body is thrown up, the force of gravity is:

a. in the upward direction
b. in the downward direction
c. zero
d. in the horizontal direction

Q 3. A particle is taken to a height R above the Earth's surface, where, R is the radius of the Earth. The acceleration due to gravity there is:

a. 2.45 m/s^2 b. 4.9 m/s^2

c. 9.8 m/s^2 d. 19.6 m/s^2

Q 4. A particle is dropped from a tower 180 m high. How long does it take to reach the ground? (Take $g = 10$ m/s^2.)

a. 6 s b. 4.25 s

c. 18 s d. 9 s

Q 5. A ball is thrown up with a speed of 15 m/s. How high will it go before it begins to fall? (Take $g = 9.8$ m/s^2)

a. 19.6 m b. 14.3 m

c. 20 m d. 11.4 m

Answers

1. (b) mass of falling body

We know that,

$g = G = \frac{M}{R^2}$, where G = universal gravitation constant, M = mass of the Earth and R = radius of the Earth.

So, g does not depend on the mass of the falling body.

2. (b) In the downward direction

The acceleration due to gravity is always directed downwards towards the centre of the Earth for a freely falling body.

3. (a) 2.45 m/s^2

It is known that $g = \frac{GM}{R^2} = 9.8$ m/s^2

When distance from centre of Earth $= 2R$,

$$g' = \frac{GM}{(2R)^2} = \frac{1}{4}\left(\frac{GM}{R^2}\right)$$

$$= \frac{1}{4} \times 9.8 = 2.45\ m/s^2$$

4. (a) 6 s

Here, $u = 0$, $h = 180$ m, $g = 10$ m/s^2, $t = ?$

From, $h = ut + 0.5\ gt^2$

$180 = 0 + 0.5\ (10)t^2$

$t^2 = 36$

or, $t = 6$ s

5. (d) 11.4 m

Here, $u = 15$ m/s, $v = 0$ (The ball stops),

$g = -9.8$ m/s^2, $h = ?$

From, $v^2 = u^2 + 2gh$

$(0)^2 = (15)^2 + 2 \times (-9.8) \times h$

$19.6\ h = 225$

or $h = 11.4$ m

Case Study 3

Pallavi Mam was demonstrating an experiment in his class with the setup as shown in the figure below. She took an eraser, sharpener, steel spoon, plastic ruler, pencil, compass and rubber band and asked the students to place them on the surface of the water. Students observed that a few objects float on the surface of water while a few sink in water.

Read the given passage carefully and give the answer of the following questions:

Q 1. An object floats in a liquid if the buoyant force is:

a. zero
b. greater than its weight
c. less than its weight
d. equal to its weight

Q 2. An object sinks in a liquid if the buoyant force is:

a. zero
b. greater than its weight
c. less than its weight
d. equal to its weight

Q 3. The buoyant force on an object immersed in a liquid acts:

a. in the vertically upward direction
b. in the vertically downward direction
c. at an angle of 90° to the direction in which weight of the object acts
d. at an angle of 45° to the direction in which weight of the object acts

Q 4. The magnitude of buoyant force depends on the:

a. density of liquid b. volume of liquid
c. weight of the object d. viscosity of liquid

Q 5. Magnitude of buoyant force is given by:

a. Newton's first law b. Archimedes' principle
c. Newton's second law d. None of these

Answers

1. (b) greater than its weight
2. (c) less than its weight
3. (a) in the vertically upward direction

   The buoyant force on an object immersed in a liquid always acts vertically upwards, that is, in a direction opposite to the weight of the object.
4. (a) density of liquid
5. (b) Archimedes' principle

   Archimedes' principle states that 'when a body is immersed fully or partially in a fluid, it experiences an upward force (buoyant force) that is equal to the weight of the fluid displaced by it.'

Case Study 4

What do aching feet, a falling apple and the orbit of the Moon have in common? Each is caused by the gravitational force. An apple falls from a tree because of the same force acting a few metres above Earth's surface. And the Moon orbits Earth because gravity is able to supply the necessary centripetal force at a distance of hundreds of millions of metres. Sir Isaac Newton was the first scientist to precisely define the gravitational force, and to show that is could explain both falling bodies and astronomical motions.

The gravitational force is always attractive and it depends only on the masses involved and the distance between them (Newton's universal law of gravitation).

Read the given passage carefully and give the answer of the following questions:

Q 1. What is gravitational force?
Q 2. Briefly explain why Newton pondered over the existence of gravitation?
Q 3. Define the universal gravitational constant.
Q 4. State the value of *G*. Who obtained it for the first time?
Q 5. 'Several phenomena of celestial bodies were believed to be unconnected but universal law of gravitation was successful to explain them.' Mention any two phenomena.

Answers

1. All objects (with mass) in the universe attract each other. This force of attraction between objects is called the gravitational force.
2. It is said an apple fell on Newton's head when he was sitting under a tree. He thought if Earth attracts an apple, can it also attract the Moon? Is the force same in both cases? This led to the study on gravitation.
3. The universal gravitational constant is numerically equal to the force of attraction between two unit masses when they are separated by a unit distance as measured from their centres.
4. The accepted value of G is 6.673×10^{-11} N-m^2 kg^{-2}. The value of G was found out by Henry Cavendish by using a sensitive balance.
5. Two phenomena explained by universal law of gravitation are:
   (i) the force that binds us to the Earth, and
   (ii) the motion of the Moon around the Earth.

Case Study 5

The weight of a body is the force with which it is attracted towards the centre of the Earth. In other words, the force of Earth's gravity acting on a body is known as its weight. Weight is a

vector quantity having magnitude as well as direction. The weight of a body is given by $W = m \times g$ (where m = mass of the body and g = acceleration due to gravity), and since the value of g changes from place to place, therefore, the weight of a body also changes from place to place.

Read the given passage carefully and give the answer of the following questions:

Q 1. Define weight.

Q 2. Is value of 'g' same at all places on the Earth? Give reason for your answer.

Q 3. What is the mass of an object whose weight is 49 N on the Earth?

Q 4. If a planet existed whose mass was twice that of Earth and whose radius 3 times greater, how much will a 1 kg mass weigh on the planet?

Q 5. In spaceship moving in space, why does a person experience weightlessness?

Answers

1. The weight of a body is the force with which it is attracted towards the centre of the Earth.
2. The value of acceleration due to gravity, g, is not constant at all the places on the surface of the Earth. This is due to the flattening of the Earth at the poles, all the places on its surface are not at the same distance from its centre and so the value of g varies with latitude.
3. Here, $W = 49$ N, $m = ?$

   As, $W = mg, m = \frac{W}{g} = \frac{49}{9.8} = 5$ kg
4. Here, $M_p = 2\,M_e$ and $R_p = 3\,R_e$

   $m = 1$ kg, $W_p = ?$

   As, $g_e = \frac{GM_e}{R_e^2}$ and $g_p = \frac{GM_p}{R_p^2}$

   $\therefore \quad \frac{g_p}{g_e} = \frac{M_p}{R_p^2} \times \frac{R_e^2}{M_e} = \frac{M_p}{M_e} \times \left(\frac{R_e}{R_p}\right)^2$

   $g_p = g_e \times \frac{M_p}{M_e} \times \left(\frac{R_e}{R_p}\right)^2$

   or $g_p = 9.8 \times 2 \times \left(\frac{1}{3}\right)^2 = 2.17$ m/s^2

   $W_p = mg_p = 1 \times 2.17 = 2.17$ N
5. A person experiences weightlessness as in spaceship moving in space, the acceleration due to gravity is zero.

   $\because \quad W = mg$

   In space, $g = 0$

   $\therefore \quad W = 0$

Case Study 6

Pressure is defined as the physical force exerted on an object. The force applied is perpendicular to the surface of objects per unit area. The basic formula for calculating pressure is: Pressure = Force/Area.

The SI unit of measuring force is Newton (N), and the SI unit of measuring area is 'square metre' (m^2), therefore, the SI unit of measuring pressure is 'Newton per square metre' (N/m^2 or N-m^{-2}) which is also called Pascal (Pa).

Read the given passage carefully and give the answer of the following questions:

Q 1. State and define the SI unit of pressure.

Q 2. In which situation we exert more pressure on ground, when we stand on one foot or on the both feet? Justify your answer.

Q 3. Which will exert more pressure: a 100 kg mass on the area of 10 m^2 or a 50 kg mass on 4 m^2?

Q 4. When we stand on loose sand, our feet go deep into the sand. But when we lie down on the sand our body does not go that deep into the sand. But when we lie down on the sand our body does not go that deep in the sand. Why?

Q 5. Why are railway tracks laid on large size concrete sleepers?

Answers

1. SI unit of pressure is N/m^2 or Pascal (Pa).

   When a force of 1 N acts normally on an area of 1 m^2 then pressure acting on the surface is called 1 Pascal.
2. The surface area of one foot is less than two feet. Therefore, we exert more pressure on the ground when we stand on one foot as pressure is inversely proportional to area of contact.
3. $P_1 = \frac{\text{Force}}{\text{Area}} = \frac{m \times g}{(\text{Area})_1} = \frac{100 \times 10}{10} = 100$ Pa

   $P_2 = \frac{\text{Force}}{\text{Area}} = \frac{M \times g}{(\text{Area})_2} = \frac{50 \times 10}{4} = 125$ Pa

   $\therefore$ 50 kg mass on 4 m^2 exerts more pressure.
4. When we stand, we apply more pressure than when we are lying due to less area of contact as

   Pressure $\propto \frac{1}{\text{Area}}$.
5. Concrete sleepers are laid on railway tracks so that the weight of passing train is spread over a large area of ground. This reduces the pressure acting on the ground and the track may not sink into the ground.

Very Short Answer Type Questions

Q 1. Which force is responsible for the motion of Moon around the Earth? What would happen if there was no such force?

Ans. The motion of Moon around the Earth is due to the centripetal force provided by the force of attraction of Earth. If there was no such force, the Moon would pursue a uniform straight line motion.

Q 2. If gravitational force acts between all objects, why don't the two objects in a room move towards each other?

Ans. The two objects in a room do not move towards each other because of their small masses, the gravitational force of attraction between them is very, very weak.

Q 3. State the universal law of gravitation. *(NCERT INTEXT)*

Ans. The universal law of gravitation states that the force of attraction between any two objects is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.

Q 4. Write the formula for magnitude of gravitational force between the Earth and an object on the surface of the Earth. *(NCERT INTEXT)*

Ans. The formula for magnitude of gravitational force between the Earth and an object on the surface of the Earth is given by $F = G = \frac{Mm}{R^2}$

where, M = mass of Earth

m = mass of an object

G = gravitational constant

$= 6.67 \times 10^{-11}$ N-m^2 /kg^2

and R = distance between centres of the Earth and an object.

Q 5. What do you mean by free fall? *(NCERT INTEXT)*

Ans. The falling of a body or object from a height towards the Earth under the gravitational force of the Earth alone is called free fall.

Q 6. What do we call gravitational force between the Earth and an object. *(NCERT EXERCISE)*

Ans. The gravitational force between the Earth and an object is called force of gravity or gravity.

Q 7. What do you mean by acceleration due to gravity. *(NCERT INTEXT)*

Or

What is the acceleration of free fall? *(NCERT EXERCISE)*

Ans. During free fall, an object accelerates due to the Earth's gravitational force acting on it. This acceleration is called the acceleration due to gravity. The value of acceleration due to gravity of Earth, g is 9.8 m/s^2.

Q 8. State the SI unit of (i) G, (ii) g.

Ans. (i) SI unit of G is N-m^2 kg^{-2}.

(ii) SI unit of g is m s^{-2}.

Q 9. What is the difference between gravity and gravitation?

Ans. Gravitation is the attractive force between any two objects in the universe whereas gravity is the gravitational force that occurs between the Earth and other objects.

Q 10. Gravitational force acts on all objects in proportion to their masses. Why, then a heavy object does not fall faster than a light object? *(NCERT EXERCISE)*

Ans. Acceleration due to gravity (g) is independent of mass of the falling object and is equal for all objects at a point. So, a heavy object falls with same acceleration as light object.

Q 11. When a body is thrown upwards, its velocity becomes zero at the highest point. What will be its acceleration at this point?

Ans. The acceleration at this point is equal to the value of g in the downward direction.

Q 12. Two objects of masses m_1 and m_2 are dropped in vacuum from a height above the surface of Earth (m_1 is greater than m_2). Which one will reach the ground first and why?

Ans. Both objects will reach the ground simultaneously because acceleration due to gravity is independent of mass of the falling objects.

Q 13. A stone is released from the top of a tower of height 19.6 m. Calculate its final velocity just before touching the ground. *(NCERT EXERCISE)*

Sol. Given, height, $h = 19.6$ m

Initial velocity, $u = 0$ [$\because$ it starts from rest]

From the third equation of motion, $v^2 = u^2 + 2gh$

$v^2 = 0 + 2 \times 9.8 \times 19.6 = 19.6 \times 19.6$

$\therefore \quad v^2 = 19.6 \times 19.6 = 19.6$ m/s

Final velocity of stone just before touching the ground is 19.6 m/s.

Q 14. What is the weight of an object at the centre of the Earth?

Ans. Zero, because at the centre of the Earth, $g = 0$.

Q 15. How does the weight of a body vary from poles to equator?

Ans. The weight of a body decreases from poles to equator because the force of gravitation is more at poles than at the equator.

Q 16. What do you mean by buoyancy? *(NCERT INTEXT)*

Ans. The upward force exerted by a liquid on any object immersed in it is known as buoyant force or upthrust.

Q 17. A bucket of water weighs less inside the well water. Why?

Ans. This is due to the upthrust that well water exerts on the bottom of bucket in upward direction.

Knowledge BOOSTER

Upthrust pushes an object up and makes it seem to lose weight in a fluid.

Q 18. The cutting edge of a knife should be as sharp as possible. Why?

Ans. A sharp knife has a very thin edge due to which the force of our hand falls over a very small area of the object producing a large pressure and this large pressure cuts the object easily.

Q 19. Why does a truck or a motor bus have much wider tyres?

Ans. A truck or a motor bus have much wider tyres, so that the pressure applied by the truck is much less as a result of which it moves easily.

Q 20. Why does a block of plastic released under water, come up to the surface of water? *(NCERT EXERCISE)*

Ans. The upthrust or buoyant force acting on the block of plastic by the water is greater than the weight of the plastic block. So, plastic block comes up to the surface of water.

Q 21. The volume of 50 g of a substance is 20 cm^3. If the density of water is 1 g cm^{-3}, will the substance float or sink? *(NCERT EXERCISE)*

Ans. Given, mass of substance, $m = 50$ g

Volume of substance, $V = 20\ cm^3$

$\therefore$ Density of substance,

$$\rho = \frac{\text{Mass}}{\text{Volume}} = \frac{50}{20} = 2.5\ g\ cm^{-3}$$
$$= 2500\ kg\ cm^{-3}$$

i.e., the density of the substance is greater than the density of water, so it will sink in water.

Q 22. A student listed applications of some principles as follows:

Submarines, Lactometers, Hydrometers, Barometers

Identify the applications of Archimedes' principle from the list.

Ans. Submarines, Lactometers and Hydrometers.

Q 23. Name the instrument which is used to determine the density of liquid.

Ans. The instrument used to determine the density of liquid is 'hydrometer'.

Short Answer Type-I Questions

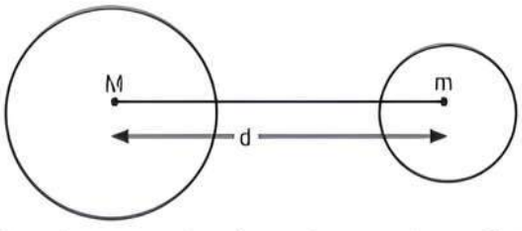
Q 1. What is the source of centripetal force that a planet requires to revolve around the Sun? On what factors does that force depend?

Ans. Gravitational force is the source of centripetal force required to revolve around the Sun.

This force depends on the masses of Sun and the planet as well as the distance between them.

Q 2. Derive the formula for the gravitational force using the factors on which it depends.

Ans. According to the universal law of gravitation, the gravitational force (F) between two objects of masses M and m at a distance 'd' from each other is:



(I) directly proportional to the product of their masses, *i.e.*, $F \propto M \times m$ .... (1)

(II) inversely proportional to the square of distance between them, *i.e.*, $F \propto \frac{1}{d^2}$ ....(2)

Combining eqs. (1) and (2), we get

$$F \propto \frac{M \times m}{d^2} \Rightarrow F = G\frac{M \times m}{d^2}$$

Where, G is called the universal gravitational constant.

Q 3. Calculate the force of gravitation between the Earth and the Sun given that the mass of the Earth = 6×10^{24} kg and of the Sun = 2×10^{30} kg. The average distance between the two is 1.5×10^{11} m. *(NCERT EXERCISE)*

Sol. The force of attraction between the Earth and the Sun is given by

$$F = \frac{G M_s M_e}{r^2}$$

where, $G = 6.67 \times 10^{-11}\ N\text{-}m^2/kg^2$

Mass of the Sun, $M_s = 2 \times 10^{30}$ kg

Mass of the Earth, $M_e = 6 \times 10^{24}$ kg

Average between the Earth and the Sun $= 1.5 \times 10^{11}$ m

$$F = \frac{6.67 \times 10^{-11} \times 2 \times 10^{30} \times 6 \times 10^{24}}{(1.5 \times 10^{11})^2} = 3.6 \times 10^{22}\ N$$

Thus, the force between Earth and Sun is 3.6×10^{22} N.

Q 4. The gravitational force between two objects is 100 N. How should the distance between these objects be changed so that the force between them becomes 50 N?

Ans. Let distance between the two objects is R when $F = 100$ N.

$$F \propto \frac{1}{R^2}$$ (universal law of gravitation)

Let distance becomes R' when $F = 50$ N.

Ratio, $\frac{100}{50} = \frac{(R')^2}{R^2} \Rightarrow 2 = \frac{R'^2}{R^2} \Rightarrow \frac{R'}{R} = \sqrt{2}$

$\Rightarrow$ $R' = \sqrt{2}\,R$

i.e., distance is increased $\sqrt{2}$ times.

Q 5. What is the importance of universal law of gravitation? *(NCERT EXERCISE)*

Ans. The universal law of gravitation successfully explained several phenomena given as below:

(i) The force that binds us to the Earth.

(ii) The motion of the Moon around the Earth.

(iii) The motion of planets around the Sun.

(iv) The tides due to the Moon and the Sun.

Q 6. What is the magnitude of the gravitational force between the Earth and a 1 kg object on its surface? (Take, mass of the Earth is 6×10^{24} kg and radius of the Earth is 6.4×10^6 m.) *(NCERT EXERCISE)*

Sol. Gravitational force between the Earth and an object is given by $F = \frac{GMm}{R^2}$

where, G = gravitational constant

$= 6.67 \times 10^{-11}\ N\text{-}m^2/kg^2$

M = mass of the Earth $= 6 \times 10^{24}$ kg

R = radius of the Earth $= 6.4 \times 10^6$ m

and m = mass of an object = 1 kg

$\therefore$ $F = \frac{6.67 \times 10^{-11} \times 6 \times 10^{24} \times 1}{(6.4 \times 10^6)^2}$

$= 9.77 = 9.8$ N

Thus, magnitude of gravitational force between the Earth and 1 kg object is 9.8 N.

Q 7. (i) What is meant by the statement that acceleration due to gravity is 9.8 m s^{-2}?

(ii) Give reason for the following:

(a) A sheet of paper falls slower than when it is crumpled into a ball.

(b) A body weighs more at the poles than at equator.

Ans. (i) It means that a freely falling body accelerates at 9.8 m/s^2 towards the centre of Earth, during the course of its fall towards the Earth.

(ii) (a) The sheet of paper has larger surface area when compared to a crumpled paper ball and experiences greater air resistance during free fall. So, it falls slowly.

(b) Value of 'g' is greater at poles as compared to equator because $r_p < r_{eq}$ and $g \propto \frac{1}{r^2}$.

Hence, the weight of a body is more at the poles than at the equator.

Q 8. Amit buys few grams of gold at the poles as per the instruction of one of his friends. He hands over the same when he meets him at the equator. Will the friend agree with the weight of gold bought? If not, why?
[Hint: The value of g is greater at the poles than at equator.] *(NCERT EXERCISE)*

Ans. Let m be the mass of gold bought.

$\therefore$ Weight of gold at poles, $W_p = mg_p$

Weight of gold at equator, $W_e = mg_e$

We know that, $g \propto \frac{1}{R^2}$

Thus, the value of g is greater at poles than at the equator. Therefore, gold at equator weighs less than that at poles, *i.e.*, $w_p > w_e$. Thus, Amit's friend will not agree with the weight of the gold bought.

Q 9. An object is dropped from a certain point to fall freely under gravity. Write its equations of motion in connections of:

(i) distance travelled, time taken and its acceleration.

(ii) final velocity, acceleration and distance moved.

Ans. For a free falling object, initial velocity (u) = 0 and acceleration (a) = $+g$.

(i) Distance travelled, $s = ut + \frac{1}{2}gt^2$

$\Rightarrow$ $s = 0 + \frac{1}{2}gt^2$

$\Rightarrow$ $s = \frac{1}{2}gt^2$

(ii) Final velocity, $v^2 = u^2 + 2gh$

$v^2 = 0 + 2gh$

$\Rightarrow$ $v^2 = 2gh$

$\Rightarrow$ $v^2 = \sqrt{2gh}$

Q 10. A ball is thrown vertically upwards with a velocity of 49 m/s. Calculate

(i) the maximum height to which it rises.

(ii) the total time it takes to return to the surface of the earth. *(NCERT EXERCISE)*

Sol. Given, initial velocity, $u = 49$ m/s

(i) At maximum height final velocity of the ball becomes zero.

$\therefore$ Final velocity, $v = 0$

From the third equation of upward motion,

$v^2 = u^2 - 2gh$

$0 = (49)^2 - 2 \times 9.8 \times h$

$\therefore$ $h = \frac{(49)^2}{2 \times 9.8} = 122.5$ m

Maximum height attained = 122.5 m

(ii) Let 't' be the time taken by the ball to reach the height 122.5 m.

From the first equation of upward motion, $v = u - gt$

or $0 = 49 - 9.8 \times t$

$t = \frac{49}{9.8} = 5$ s

For the motion against gravity, the time of descent is same as the time of ascent. So, time taken by the ball to fall from maximum height is 5 s.

$\therefore$ Total time taken by the ball to return to surface of the Earth = 5 + 5 = 10 s.

Q 11. The mass of an object on the Earth's surface is 80 kg. Find its:

(i) weight on Earth

(ii) mass and weight on Moon (g_e = 9.8 m/s^2; g_m = 1.63 m/s^2).

Sol. (i) Weight on Earth = $m_e g_e$ = 80 × 9.8 = 784 N

(ii) Mass on Moon = mass on Earth = 80 kg

Weight on Moon = $\left(\frac{1}{6}\right)$ × Weight on Earth

$= \frac{784}{6} = 130.67$ N

Q 12. If the Moon attracts the Earth, then why does the Earth not move towards the Moon?

Ans. The earth does not move towards the Moon in spite of the attraction by the Moon because the mass of Earth is much greater than mass of Moon and according to second law of motion, for a given force, acceleration is inversely proportional to mass of the object.

Q 13. The weight of a body on the surface of the Earth is 392 N. What will be the weight of this body on a planet whose mass is double that of the Earth and radius is four times that of the Earth?

Sol. Mass of body = $\frac{\text{Weight on earth}}{g_e} = \frac{392}{9.8}$

= 40 kg

$$g_e = \text{'g' on Earth} = \frac{GM_e}{(R_e)^2} = 9.8 \text{ m s}^{-2}$$

where, M_e = Mass of Earth.

R_e = Radius of Earth.

Now, Mass of planet = $2M_e$. Radius of planet = $4F_e$

$$\therefore g_{planet} = \frac{GM_p}{R_p^2} = \frac{G(2M_e)}{(4R_e)^2} = \left(\frac{1}{8}\right)g_e = \left(\frac{1}{8} \times 9.8\right) = 1.225 \text{ m/s}^2$$

Weight on planet = $m \times g_{planet} = 40 \times 1.225 = 49$

Q 14. In a hypothetical case, if the diameter of the Earth becomes half of its present value and mass becomes four times its present value, then how would the weight of any object on surface of the Earth be affected?

Ans. We know that, weight, $W = mg$

As mass is constant, $W \propto g$

$$g = \frac{GM}{R^2} = 9.8 \text{ m s}^{-2} \quad \text{... (1)}$$

On modifying the values,

$$g = \frac{G(4M)}{\left(\frac{R}{2}\right)^2} = 16\,\frac{GM}{R^2} = 16 \times 9.8 \text{ m s}^{-2} \quad \text{... (2)}$$

From eqs. (1) and (2), g becomes 16 times. Hence, we conclude that the weight (W) of any object on surface of the Earth becomes 16 times.

Q 15. The weight of any person on the Moon is about $\frac{1}{6}$ times that on the Earth. He can lift a mass of 15 kg on the Earth. What will be the maximum mass which can be lifted by the same force applied by the person on the Moon?

Sol. We know that, $W_m = \frac{1}{6} W_e \Rightarrow g_m = \frac{1}{6} g_e$ ....(1)

Force required to lift mass m on Earth,

$$F_e = m \times g_e = 15\, g_e$$

Force required to lift mass m' on Moon,

$$F_m = m' \times g_m = m' g_m$$

$$F_m = F_e$$

$$15\, g_e = m' g_m$$

$$\therefore \quad m' = 15\left(\frac{g_e}{g_m}\right) = 15 \times 6 = 90 \text{ kg} \qquad \text{(from eq. (1))}$$

Hence, the maximum mass that can be lifted is 90 kg.

Q 16. Find the ratio of the pressure exerted by a block of 400 N when placed on a table top along its two different sides with dimensions 20 cm × 10 cm and 16 cm × 20 cm.

Sol.

$$A_1 = 20 \text{ cm} \times 10 \text{ cm}$$

$$= 0.2 \text{ m} \times 0.1 \text{ m} = 0.02 \text{ m}^2$$

$$A_2 = 16 \text{ cm} \times 20 \text{ cm}$$

$$= 0.16 \text{ m} \times 0.2 \text{ m} = 0.032 \text{ m}^2$$

$$P_1 = \frac{F}{A_1} = \frac{400}{0.02} = 20{,}000 \text{ Pa}$$

$$P_2 = \frac{F}{A_2} = \frac{400}{0.032} = 12{,}500 \text{ Pa}$$

$$\therefore \quad \text{Required Ratio} = \frac{20{,}000}{12{,}500} = \frac{8}{5}$$

$$\therefore \quad P_1 : P_2 = 8 : 5$$

Q 17. Why is it difficult to hold a school bag having a strap made of thin and strong string? *(NCERT INTEXT)*

Ans. It is difficult to hold a school bag having a strap made of a thin and strong string because the area under the strap is small. Hence, large pressure is exerted by the strap on the shoulder of the child and it will become very painful to carry the heavy school bag.

Q 18. Why does an object float or sink when placed on the surface of water? *(NCERT INTEXT)*

Ans. When an object is placed on the surface of water, two forces act on the object.

(i) The weight of the object, acting vertically downwards.

(ii) The upthrust of the water, acting vertically upwards.

The object will float on the surface of water, if the upthrust is greater than the weight of the object. The object will sink, if the weight of the object is more than the upthrust of the water.

Q 19. The volume of a 500 g sealed packet is 350 cm^3. Will the packet float or sink in water if the density of water is 1 g cm^{-3}? What will be the mass of the water displaced by this packet?

Sol. Given, mass of packet = 500 g

Volume of packet = 350 cm^3

$$\therefore \quad \text{Density of packet, } \rho = \frac{\text{Mass}}{\text{Volume}} = \frac{500 \text{ g}}{350 \text{ cm}^3}$$

$$= 1.43 \text{ g cm}^{-3}$$

i.e., The density of packet is greater than density of water, so it will sink in water.

Mass of water displaced by the packed

= Volume of packet × Density of water

= 350 × 1

= 350 g

Q 20. (I) State Archimedes' principle.

(ii) Explain with reason: Do all bodies in a given fluid experience the same buoyant force?

Ans. (i) Archimedes' principle states that when a body is immersed fully or partially in a fluid, it experiences an upward force that is equal to the weight of the fluid displaced by it.

(ii) No, according to Archimedes' principle, bodies with different weight will displace different weight of the fluid. Hence, the buoyant force on different objects will be different.

Short Answer Type-II Questions

Q 1. What happens to the force between two objects, if
(i) the mass of one object is doubled?
(ii) the distance between the objects is doubled and tripled?
(iii) the masses of both objects are doubled?

Ans. Force of attraction between two objects is given by

$$F = \frac{Gm_1m_2}{r^2} \quad ...(1)$$

where, m_1 and m_2 = masses of the objects,
r = distance between the objects
and G = gravitational constant.

(i) If mass of one object is doubled, then the new force,

$$F' = \frac{G(2m_1)m_2}{r^2} = 2 \times \frac{Gm_1m_2}{r^2} = 2F$$

i.e., Force becomes double.

(ii) If the distance between the objects is doubled, then the new force,

$$F' = \frac{Gm_1m_2}{(2r)^2} = \frac{Gm_1m_2}{4r^2}$$

$$= \frac{1}{4} \cdot \frac{Gm_1m_2}{r^2} \quad \text{[from eq. (1)]}$$

$$= \frac{F}{4}$$

i.e., Force becomes one-fourth.

If the distance between the objects is tripled, then new force,

$$F = \frac{Gm_1m_2}{(3r)^2} = \frac{Gm_1m_2}{9r^2}$$

$$= \frac{1}{9}\left(\frac{Gm_1m_2}{r^2}\right) = \frac{F}{9} \quad \text{[from eq. (2)]}$$

i.e., Force becomes one-ninth.

(iii) If mass of both objects are doubled, then new force,

$$F = \frac{G(2m_1)2m_2}{r^2}$$

$$= 4 \times \frac{Gm_1m_2}{r^2} = 4F \quad \text{[from eq. (1)]}$$

i.e., Force becomes four times.

Q 2. Suppose you and your friend have mass 50 kg each. Also, suppose that the distance between your centres of gravity is 1 m. Calculate the force of gravitation between you and your friend. Also calculate the force of gravity acting on you. Take the mass and radius of the Earth as 6×10^{24} kg and 6.4×10^6 m respectively.

Sol. Given, mass of each person, $m_1 = m_2 = 50$ kg
Distance between the centres of gravity, $r = 1$ m
$\therefore$ Force of gravitation,

$$F = G\frac{m_1m_2}{r^2} = 6.67 \times 10^{-11} \times \frac{50 \times 50}{(1)^2}$$

$$= 1.67 \times 10^{-7}\text{N}$$

Hence, the force of gravitation is 1.67×10^{-7}N.

We know that, force of gravity $= G\frac{m_1M}{R^2}$

Where M = mass of Earth $= 6 \times 10^{24}$ kg
and R = radius of Earth $= 6.4 \times 10^6$ m

$\therefore$ Force of gravity, $F = \frac{6.67 \times 10^{-11} \times 6 \times 10^{24} \times 50}{(6.4 \times 10^6)^2}$

$= 489$ N

Hence, the force of gravity is 489 N.

Q 3. Compare the gravitational forces exerted by the Sun and Moon on the Earth. Who exerts a greater force and by how much?

Ans. We know that,
Mass of the Earth, $M_e = 6 \times 10^{24}$ kg
Mass of the Moon, $M_m = 7.3 \times 10^{22}$ kg
Mass of the Sun, $M_s = 2 \times 10^{30}$ kg
Distance between the Earth and the Moon,

$$R_1 = 3.84 \times 10^8 \text{ m}$$

Distance between the Earth and the Sun,

$$R_2 = 1.5 \times 10^{11} \text{ m}$$

Gravitational force between the Earth and the Moon,

$$F_1 = G\frac{M_eM_m}{R_1^2}$$

$$= 6.67 \times 10^{-11} \times \frac{6 \times 10^{24} \times 7.3 \times 10^{22}}{(3.84 \times 10^8)^2}$$

$$= 2 \times 10^{20} \text{ N}$$

Similarly, gravitational force between the Earth and the Sun,

$$F_2 = G\frac{M_eM_s}{R_2^2}$$

$$= 6.67 \times 10^{-11} \times \frac{6 \times 10^{24} \times 2 \times 10^{30}}{(1.5 \times 10^{11})^2}$$

$$= 3.6 \times 10^{22} \text{ N}$$

$\therefore$ $\frac{F_2}{F_1} = \frac{3.6 \times 10^{22}}{2 \times 10^{20}} = 180$

Hence, the Sun exerts 180 times greater force than the Moon.

Q 4. Write the differences between acceleration due to gravity (g) and universal gravitational constant (G).

Ans. Difference between acceleration due to gravity and universal gravitational constant is as follows:

Basis of Difference	Acceleration due to Gravity (g)	Universal Gravitational Constant (G)
Definition	Acceleration due to gravity is the acceleration acquired by a body due to the Earth's gravitational pull on it.	Universal Gravitational constant is numerically equal to the force of attraction between two masses of 1 kg that are separated by a distance of 1 m.
Nature	g is a vector quantity.	G is a scalar quantity.

Effect on value	It is different at different places on the surface of the Earth. Its value also varies from one celestial body to another.	G is a universal constant *i.e.*, its value is the same (*i.e.*, 6.7 $\times 10^{-11}$ N-m^2 kg^2) everywhere in the universe.

Q 5. A stone is thrown vertically upward with an initial velocity of 40 m/s. Taking $g = 10$ m/s^2, find the maximum height reached by the stone. What is the net displacement and the total distance covered by the stone? *(NCERT EXERCISE)*

Sol. Given, Initial velocity, $u = 40$ m/s

Final velocity becomes zero, *i.e.*, $v = 0$ (at maximum height)

From third equation of upward motion,

$$v^2 = u^2 - 2gh$$

$$(0)^2 = (40)^2 - 2 \times 10 \times h$$

$$0 = 1600 - 20h$$

$$\Rightarrow \quad h = \frac{1600}{20} = 80 \text{ m}$$

$\Rightarrow$ Maximum height reached by the stone = 80 m.

After reaching the maximum height, the stone will fall towards the Earth and will reach the Earth's surface covering the same distance.

So, distance covered by the stone = 80 + 80 = 160 m.

Displacement of the stone = 0, since, the initial and final position of the stone are same.

Q 6. A ball is dropped from the jumping board of swimming pool, which is at a height of 20 m. A second ball is thrown from the same board after one second with initial velocity u. Both the balls hit the surface of water together. What was the initial velocity with which the second ball was thrown? Do they hit the surface of water with the same velocity? Explain your answer.

Sol. Given, height of the jumping board, $h = 20$ m

For first ball, Initial velocity, $u_1 = 0$

$$g = 10 \text{ m s}^{-2}$$

Time taken for the first ball to fall freely, $t = ?$

From the equation of motion,

$$h = u_1 t + \frac{1}{2} g t^2$$

$$= 0 \times t + \frac{1}{2} g t^2$$

or $$t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2 \times 20}{10}} = \sqrt{4}$$

$$= 2 \text{ s}$$

Also, $v = u + gt$

$\therefore$ Final velocity of first ball, $v_1 = 0 + (10) \times 2$

$= 20$ m/s

Thus, the second ball thrown after 1 s with the initial velocity u_2 should cover a distance of 20 m in 1s.

Considering the second ball, we have

$$h = u_2 t + \frac{1}{2} g t^2$$

$$\Rightarrow \quad 20 = u_2 \times 1 + \frac{1}{2} \times 10 \times (1)^2 \quad (\because g = 10 \text{ m s}^{-2})$$

or $$u_2 = 20 - 5 = 15 \text{ m s}^{-1}$$

Hence, the initial velocity with which the second ball was thrown is 15 m s^{-1}.

Using, $v = u + gt$,

Final velocity of second ball $v_2 = 15 + (10 \times 1)$

$= 25$ m/s

Hence, both the balls will not hit the surface of water with the same velocity, *i.e.*, the second ball hits the surface of water with a greater velocity.

Q 7. A ball is thrown upwards from the ground to a tower with a speed of 20 m s^{-1}. There is a window in the tower at a height of 15 m from the ground. How many times and when will the ball pass the window? (Take $g = 10$ m s^{-2})

Sol. Given, initial velocity, $u = 20$ m s^{-1}.

Maximum height the ball will reach, $h = ?$

From the equation of motion,

$$v^2 = u^2 + 2gh$$

$$0 = u^2 + 2gh \quad (\because v = 0 \text{ at maximum height})$$

or $$h = \frac{-u^2}{2g} = \frac{-(20)^2}{2(-10)}$$

$$= \frac{400}{20} = 20 \text{ m}$$

This means that ball will reach the height of 20 m and come back. So, it will pass the window two times.

From the equation of motion,

$$h = ut - \frac{1}{2} g t^2$$

$$15 = 20t - \frac{1}{2}(10)t^2$$

or $$5t^2 - 20t + 15 = 0$$

or $$t^2 - 4t + 3 = 0$$

or $$(t - 1)(t - 3) = 0$$

$\therefore$ $$t = 1, 3$$

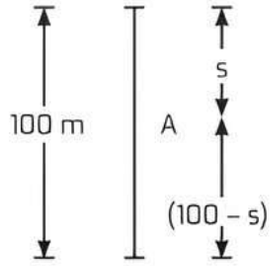
So, the ball will pass the window at 1 second and 3 seconds respectively.

Q 8. A stone is allowed to fall from the top of a tower 100 m high and at the same time, another stone is projected vertically upwards from the ground with a velocity of 25 m/s. Calculate when and where the two stones will meet. *(NCERT EXERCISE)*

Sol. Let the two stones meet at point 'A' after time 't'.

Distance travelled by the stone dropped = s

$\therefore$ Distance travelled by the stone projected upwards = (100 – s) m



For stone dropped from top, $u = 0$

For stone projected upwards, $u' = 25$ m/s

For the stone dropped from the tower,

$$s = ut + \frac{1}{2}gt^2$$

$$= 0 + \frac{1}{2}(10)t^2$$

$$s = 5t^2 \quad \text{...(1)}$$

For the stone projected upwards, $s' = ut - \frac{1}{2}gt^2$

(due to upward motion, negative sign is taken)

$$(100 - s) = 25t - \frac{1}{2} \times 10t^2$$

$$\Rightarrow \quad 100 - s = 25t - 5t^2$$

From Eq. (1), we get

$$100 - 5t^2 = 25t - 5t^2$$

$$25t = 100$$

$$\Rightarrow \quad t = 4 \text{ s}$$

So, the stones will meet after 4s.

$$s = 5t^2 = 5 \times (4)^2$$

$$= 80 \text{ m}$$

Thus, the stones will meet at a height of 20m (100 m – 80 m) from the ground after 4 seconds.

Q 9. A ball thrown up vertically returns to the thrower after 6 s, find

(i) the velocity with which it was thrown up,

(ii) the maximum height if reach and

(iii) its position after 4 s. *(NCERT EXERCISE)*

Sol. Total time taken = 6 s

$\therefore$ Time taken to reach the maximum height $= \frac{6}{2} = 3$ s

($\because$ time of ascent = time of descent)

(i) From the first equation of motion, $v = u - gt$

(negative sign is taken due to upward motion)

$$0 = u - 10 \times 3 \quad (\because \text{at maximum height, } v = 0)$$

$$\Rightarrow \quad u = 30 \text{ m/s}$$

(ii) From the third equation of motion

$$v^2 = u^2 - 2gh$$

(negative sign is taken due to upward motion)

$$0 = (30)^2 - 2 \times 10 \times h$$

$$\Rightarrow \quad h = \frac{(30)^2}{2 \times 10}$$

$$= 45 \text{ m}$$

Maximum height attained by the ball is 45 m.

(iii) In initial 3 s, the ball will rise, then in next 3 s it falls towards the Earth.

$\therefore$ The position after 4 s

= Distance covered in 1 s in the downward motion

In this case, initial velocity = 0

From the second equation of motion,

$$h = ut + \frac{1}{2}gt^2$$

$$= 0 + \frac{1}{2} \times 10 \times (1)^2 = 5 \text{ m}$$

i.e., The ball will be at 5 m below from the top of the tower or the height of ball from the ground will be at 40 m (45 m – 5 m).

Q 10. A helicopter is on a mission to drop food for some people standing on a boat. It is at a height of 20 m and moving with a steady horizontal velocity of 2 m s^{-1}, when it spots the nearest end of the boat immediately below it. It then drops the packets. If the length of the boat is 5 m, will the people in the boat receive the packets?

Sol. Given, initial velocity of packet while dropping, $u = 0$

Height of packet, $h = 20$ m

Length of boat, $x = 5$ m

Let the packet takes 't' sec to fall on boat.

From the equation of motion, $h = ut + \frac{1}{2}gt^2$

or $\quad 20 = 0 \times t + \frac{1}{2} \times 10 \times t^2$

or $\quad t^2 = \frac{20 \times 2}{10} = 4$

or $\quad t = 2$ sec

Now, velocity in horizontal direction,

$v = 2$ m s^{-1} = Velocity of helicopter

Also, acceleration is zero in horizontal direction.

So, horizontal distance covered by packet in 2 sec,

$$x = vt = 2 \times 2 = 4 \text{ m}$$

Since, 4 m distance covered in dropping of packet is less than the length of boat, *i.e.*, 5 m, so people in the boat will receive the packets.

Q 11. What are the differences between the mass of an object and its weight?

Ans. Difference between mass and weight.

Basis of Difference	Mass	Weight
Definition	Mass is the quantity of matter contained in a body.	Weight of a body is the force with which a body is attracted towards the centre of the Earth.
Effect on value	Its value remains constant irrespective of its location.	Its value ($W = mg$) changes from one place to another due to the change in the value of acceleration due to gravity 'g'.
Nature	It is a scalar quantity.	It is a vector quantity.
Measuring instrument	It is measured by a beam balance.	It is measured by a spring balance.
Value	Mass of a body is never zero.	Weight of a body is zero at the centre of the Earth.
Unit	Its unit is kg.	Its unit is Newton.

Q 12. There are two kinds of balances, that is, a beam balance and a spring balance. If both the balances give the same measure of a given body on the surface of the Earth, will they give the same measure on the surface of Moon? Explain your answer.

Ans. The beam balance is a device used for the determination of mass of a body. The mass of a body is constant and does not change from place to place.

Spring balance is used to measure the weight of an object. The weight of a body is not constant and also changes from place to place.

On the surface of Moon, the beam balance will show the same reading as it shows on Earth because mass is a universal quantity. However, the spring balance shows a weight which is one-sixth of the measure on the surface of the Earth, because the acceleration due to gravity on the surface of the Moon is one-sixth of the acceleration due to gravity on the surface of the Earth.

Q 13. Define pressure and state its SI unit. Give two practical daily life applications that make use of the concept of pressure.

Ans. The thrust on unit area is called pressure. Its SI unit is N/m^2 or Pascal (Pa).

Practical daily life applications based on the concept of pressure are as follows:

(i) A school bag has wide strap made of thick cloth so that weight of bag fall over a large area producing less pressure on the shoulder of child.

(ii) We use sharp knife to cut objects compared to blunt knife because for given amount of force sharp knife cuts more easily because of high pressure.

Q 14. (i) Explain buoyancy and buoyant force.

(ii) When an aluminium object is immersed in water, it displaces 5 kg of water. How much is the buoyant force acting on the aluminium object is Newton? ($g = 10\ m/s^2$)

Ans. (i) The tendency of a liquid to exert an upward force on an object placed in it is called buoyancy.

The upward force exerted by the fluid on an object immersed in it is called buoyant force or upthrust.

(ii) Here, mass of water (m) = 5 kg, $g = 10\ m/s^2$

According to Archimedes' principle,

buoyant force acting on aluminium object = weight of water displaced by this aluminium object

Weight of water = $m \times g = 5 \times 10 = 50$ N

∴ Buoyant force acting on aluminium object = 50 N.

Long Answer Type Questions

Q 1. (i) Prove that if the Earth attracts two bodies placed at the same distance from the centre of the Earth with equal force, then their masses will be the same.

(ii) Mathematically express the acceleration due to gravity in terms of mass of the Earth and radius of the Earth.

(iii) Why is G called a universal constant?

Ans. (i) Let the two bodies have masses m_1 and m_2 and they are placed at the same distance R from the centre of the Earth.

Let F_1 and F_2 be the forces acting on them.

Then, $F_1 = \frac{GMm_1}{R^2}$ ...(1)

and $F_2 = \frac{GMm_2}{R^2}$ ...(2)

$\because F_1 = F_2$ (Given)

$\therefore \frac{GMm_1}{R^2} = \frac{GMm_2}{R^2}$

Hence, $m_1 = m_2$, i.e., their masses will be the same.

(ii) Mathematically, $g = \frac{GM}{R^2}$

where, g = acceleration due to gravity

G = universal gravitational constant

M = mass of the Earth

and R = radius of the Earth

(iii) G is known as the universal gravitational constant because its value always remains same everywhere in the universe and is applicable to all bodies whether they are celestial or terrestrial.

Knowledge BOOSTER

Celestial bodies are the bodies in the space such as Sun, Moon, planets and Stars. Terrestrial bodies are the bodies on Earth such as human beings.

Q 2. (i) A person weighs 110.84 N on Moon surface, whose acceleration due to gravity is 1/6th of that of Earth. If the value of g on Earth is 9.8 m s^{-2}, calculate the (a) g on the Moon, (b) mass of person on the moon and (c) weight of person on the Earth.

(ii) How does the value of g on the Earth is related to the mass of the Earth and its radius? Derive it.

Sol. (i) (a) Let g' be the acceleration due to gravity on Moon

$$g' = \frac{g}{6} = \frac{9.8}{6} = 1.63\ m\ s^{-2}$$

(b) Mass of the person on the Moon

$$= \frac{110.84}{1.63} = 68\ kg$$

(c) Weight of the person on the earth

$$= mg = 68 \times 9.8 = 666.4\ N$$

(ii) Let mass of the Earth be M and an object falling freely towards it be m. The distance between centres of Earth and the object is R.

From Newton's law of gravitation,

$$F = \frac{GMm}{R^2} \quad ...(1)$$

Also from second law of motion, force exerted on object,

$F = ma$

Since, $a = g$ (i.e., acceleration due to gravity)

$F = mg$ ...(2)

Equating both eqs. (1) and (2),

We get, $mg = \frac{GMm}{R^2}$ or $g = \frac{GM}{R^2}$

Q 3. The radius of the Earth at the poles is 6357 km and the radius at the equator is 6378 km. Calculate the percentage change in the weight of a body when it is taken from the equator to the poles.

Sol. Let the acceleration due to gravity at equator be g_e

where, $g_e = \frac{GM_e}{R_e^2}$

and the acceleration due to gravity at poles be g_p

where, $g_p = \frac{GM_e}{R_p^2}$

The variation of acceleration due to gravity,

$$\Delta g = g_p - g_e = GM_e\left(\frac{1}{R_p^2} - \frac{1}{R_e^2}\right)$$

Percentage variation in $g = \frac{\Delta g}{g_e} \times 100$

$$= \frac{GM_e\left(\frac{1}{R_p^2} - \frac{1}{R_e^2}\right)}{\frac{GM_e}{R_e^2}} \times 100$$

$$= \frac{R_e^2 - R_p^2}{R_e^2 R_p^2} \times 100 \times R_e^2$$

$$= \frac{R_e^2 - R_p^2}{R_p^2} \times 100$$

$$= \frac{(6378)^2 - (6357)^2}{(6357)^2} \times 100 = 0.7\%$$

Hence, % variation in the weight of a body is 0.7% which is equal to the % change in g.

Q 4. Two objects of masses m_1 and m_2 having the same size are dropped simultaneously from heights h_1 and h_2, respectively. Find out the ratio of time they would take in reaching the ground. Will this ratio remain the same, if

(i) One of the objects is hollow and the other one is solid.

(ii) Both of them are hollow and size remains the same in each case? Give reason.

Ans. We know that, $h = ut + \frac{1}{2}gt^2$

$$h = \frac{1}{2}gt^2 \qquad (\because u = 0)$$

Let 't_1' and 't_2' be the time taken by objects A and B to reach the ground.

Height of object A, $h_1 = \frac{1}{2}gt_1^2$

and height of object B, $h_2 = \frac{1}{2}gt_2^2$

$\therefore$ $h_1 : h_2 = t_1^2 : t_2^2$

or $t_1 : t_2 = \sqrt{h_1} : \sqrt{h_2}$

(i) Acceleration due to gravity is independent of the mass of falling body. So, the ratio will remain the same.

i.e., $t_1 : t_2 = \sqrt{h_1} : \sqrt{h_2}$

(ii) If both the bodies are hollow, then also the ratio will remain the same, i.e., $t_1 : t_2 = \sqrt{h_1} : \sqrt{h_2}$

Q 5. (i) Enlist two forces which act on a body when it is immersed in a liquid. State the condition for a body to float or sink in a liquid.

(ii) Why does an iron nail sink and a piece of wood floats? Explain how?

(iii) Why do you prefer a broad and thick handle of your suitcase?

(iv) The mass of an iron cube having an edge length 1.5 cm is 50 g. Find its density.

Ans. (i) The two forces that act on a body when it is immersed in a liquid are buoyant force and gravitational force.

The conditions for a body to float or sink in a liquid are as follows:

(a) If the weight of the body is more than the upthrust acting on it, the body will sink.

$\therefore$ $W > U$ (sink)

(b) If the weight of the body is less than the upthrust acting on it, the body will float.

$\therefore$ $W < U$ (float)

(ii) Iron has more density than water so an iron nail sinks in water. But the density of wood is less than that of water, therefore, a piece of wood floats in water.

(iii) Since, pressure acting on the body is inversely proportional to the surface area of contact.

$\therefore$ $P \propto \frac{1}{A}$

Hence, less pressure will act on the body if the area of contact is more. The broad and thick handle of suitcase has large area, so less pressure acts on our hand and it becomes very easy to take it from one place to another.

(iv) Given, mass of the cube = 50 g

Side of cube = 1.5 cm

$\therefore$ Volume of cube = $(1.5)^3 = 3.375\ cm^3$

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

$$= \frac{50}{3.375} = 14.81\ g\ cm^{-1}$$

So, the density of iron cube is 14.81 g cm^{-3}.

Q 6. (i) Why does a cork released under water come up to the surface of water?

(ii) Why does an army tank rest upon a continuous chain?

(iii) How does snow shoes stop you from sinking into snow?

(iv) Why are the railway tracks laid on large sized concrete sleepers?

(v) Why is it easier to swim in sea water than in river water?

Ans. (i) The density of cork is less than that of water, *i.e.*, its weight is less than the buoyant force experienced by it under water. So, when this cork is released under water, it comes up to the surface of water.

(ii) An army tank is very heavy and applies greater pressure on the ground. So, to avoid sinking in the ground, a continuous chain is used so as to increase the surface area of the tank. This chain decreases the pressure applied by the tank on the ground and it moves easily.

(iii) Snow shoes have large, flat base and hence, there is more area of contact. So, there is less pressure on the snow and the person does not sink.

(iv) Due to large size of the concrete sleepers, the weight of the train spreads over a larger area and the pressure exerted is less and the railway tracks does not sink into the ground. Hence, the railway tracks are laid on large-sized concrete sleepers.

(v) Sea water has a higher density than river water. So, it will exert higher buoyant force than river water on the same object. Hence, in order to swim, less amount of water needs to be displaced. Therefore, it is easier to swim in sea water.

Q 7. Differentiate between thrust and pressure. (Give two points)

What do you understand by 1 Pascal and 1 Newton? How will the pressure change if area of contact is doubled?

Ans. Difference between thrust and pressure:

Basis of Difference	Thrust	Pressure
Definition	The force acting on an object perpendicular to its surface is called thrust.	Thrust per unit area of a surface is called pressure.
SI unit	The SI unit of thrust is Newton.	The SI unit of pressure is Pascal or N/m^2.

1 Pascal: Pressure acting on a surface is one pascal if a thrust of one Newton acts perpendicularly upon an area of 1 m^2.

1 Pa = 1 N/1 m^2 = 1 N/m^2

1 Newton: Thrust exerted on a surface is one newton if it accelerates a body of unit mass by 1 m/s^2 while acting perpendicular to it.

If area of contact is doubled, pressure becomes half as pressure is inversely proportional to area.

Chapter Test

Multiple Choice Questions

Q 1. The mass of a ball is four times the mass of another ball. When these balls are separated by a distance of 10 cm, the gravitational force between them is 6.67×10^{-7} N. The masses of the two balls are:

a. 10 kg, 40 kg
b. 5 kg, 20 kg
c. 20 kg, 30 kg
d. 15 kg, 60 kg

Q 2. A man weighs 600 N on Earth. What would be his approximate weight on Moon?

a. 100 N b. 200 N
c. 60 N d. 600 N

Q 3. A man first swims in sea water and them in river water. Compare the weights of sea water and river water displaced by him.

a. Weight of sea water > Weight of river water
b. Weight of sea water = Weight of river water
c. Weight of sea water < Weight of river water
d. None of the above

Q 4. Consider the following information in respect of four objects A, B, C and D:

Object	Density (kg/m^3)	Volume (m^3)	Mass (kg)
A		2	4000
B	8000	4	
C	2000		1000
D		4	2000

Which object would float on water?

a. A b. B c. C d. D

Assertion and Reason Type Questions

Directions (Q. Nos. 5-6): *Each of the following questions consists of two statements, one is* ***Assertion*** *(A) and the other is* ***Reason*** *(R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below:*

a. Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
b. Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).

c. Assertion (A) is true but Reason (R) is false.
d. Assertion (A) is false but Reason (R) is true.

Q 5. **Assertion (A):** The value of g does not depend upon mass of the body.
Reason (R): Acceleration due to gravity is a constant quantity.

Q 6. **Assertion (A):** The Moon revolves around the Earth due to gravitational force between Moon and Earth.
Reason (R): Gravitational force between Moon and Earth is calculated by Newton's law of gravitation.

Case Study Based Question

Q 7. Ashish is a student of class IX in a Rajasthan School. This year all the students of class IX were going to visit Kashmir during the winter holidays along with some of their teachers.
All the students were asked to pack heavy woollen clothes with them because winter in Kashmir is very severe. Ashish had recently studied a particular chapter in science. Keeping that in mind, Ashish also purchased a pair of special type of shoes from the market and packed it along with his luggage. When the students reached Srinagar, it was extremely cold. When the students got up in the morning next day, they were told that heavy snowfall is going on in this area since last night and that there were thick layers of snow all around their hotel. Most of the students had not seen snowfall before. So, all the students and teachers decided to walk and play on fresh falling snow. Ashish put on his special shoes while walking on snow. It was noticed that the feet of all other students and teachers wearing ordinary shoes were sinking into soft snow making it very difficult for them to walk on soft snow. But this was not so with Ashish. Ashish could walk easily even on soft snow (without his feet sinking into it). All the students were very jealous of Ashish. But the teachers were all praise for Ashish.

Read the given passage carefully and give the answer of the following questions:

(i) Define the concept of science involved in the incident which took place on soft snow?
(ii) Why do the feet of a student wearing ordinary shoes sink into soft snow?
(iii) What are the special shoes worn by Ashish called? How do they differ from ordinary shoes?
(iv) Explain why, by wearing special shoes, Ashish could walk easily on soft snow (without his feet sinking into soft snow).

Very Short Answer Type Questions

Q 8. In what direction, does the buoyant force on an object immersed in a liquid act?

Q 9. Thrust of 'F' N is exerted on an area 2A and thrust of '$3F$' N is exerted on an area $A/2$. Find the ratio of pressure exerted.

Short Answer Type-I Questions

Q 10. If the distance between two masses be increased by a factor of 6, by what factor would the mass of one of them to be altered to maintain the same gravitational force?

Q 11. (i) The head of a pin is flat and thick whereas its tip is fine and thin. Explain why?
(ii) Why do we feel lighter when we swim?

Q 12. (i) Weight of an object will be lesser or more at Antarctica as compared to weight of object at Delhi. Give reason for your answer.
(ii) Find the weight of Ajay whose mass is 58 kg. (g = 10 m s^{-2})

Short Answer Type-II Questions

Q 13. (i) What is meant by free fall?
(ii) A boy throws a ball vertically upwards and catches it back in 10 s. Calculate
(a) the velocity with which it was thrown up.
(b) maximum height attained by the ball.
(Take g = 10 m s^{-2})

Q 14. (i) State the principle on which the working of lactometers is based.
(ii) What is meant by buoyancy? On what factors does the magnitude of an buoyant force experienced by a body in a fluid depend?

Q 15. (i) Derive an expression for acceleration for an object falling freely.
(ii) Give one example each where the same force acting on (i) a smaller area exerts a larger pressure, (ii) a larger area exerts a smaller pressure.

Long Answer Type Questions

Q 16. (i) State universal law of gravitation.
(ii) Differentiate between acceleration due to gravity and universal gravitational constant.
(iii) Why will a sheet of paper fall slower than one that is crumpled into a ball?

Q 17. (i) Radius of an iron sphere is 0.21 cm. If density of iron is 7.8 g/cm^3, calculate its mass.
(ii) A pressure of 1000 Pa acts on a surface of area 15 cm^2 by a block of mass 'm'. Calculate 'm' and the new pressure exerted by the same block if area of contact with the surface becomes 10 cm^2.